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**BE IT KNOWN** that **WE**, Friedrich-Georg Schröder, Roland Hochhaus, Bernd Weitzel, Bernd Hoppe, Hermann Lemm, Gerhard Hahn and Hans-Walter Abraham, citizens of Germany, whose post office addresses and residencies are, respectively, Bahnhofstrasse 58, 55218 Ingelheim, Germany; Ludwig-Schwamb 5 Strasse 43, 55126 Mainz, Germany; Gotenstrasse 8, 55597 Wöllstein, Germany; Mainzer Strasse 52A, 55218 Ingelheim, Germany; Rheinhöhenstrasse 53, 55430 Dellhofen, Germany; Auf der neuen Heide 1, 55595 Allenfeld, Germany; and Roquetteweg 26, 64285 Darmstadt, Germany; have invented certain new and useful improvements in a

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**PROCESS FOR PARTIAL SHAPING OF FLAT GLASS OR  
GLASS-CERAMIC ARTICLES AND APPARATUS FOR  
PERFORMING SAME**

of which the following is a complete specification thereof:

## **BACKGROUND OF THE INVENTION**

### **1. Field of the Invention**

The present invention relates to a process for partial shaping of flat glass  
5 or comparable glass-ceramic articles. It also relates to an apparatus for  
performing that process.

### **2. Description of the Related Art**

A pre-shaped flat glass article, which comes in the form of a table or in the  
form of an endless sheet, and/or a correspondingly formed glass-ceramic article,  
10 frequently must be partially shaped for certain application purposes. This shaping  
includes, for example, the formation of a turned up or raised edge region around  
a hole, the flanging of an outer edge or the formation of depressed or raised  
regions in glassy table tops, glass doors or glass-ceramic cook tops.

In practice different shaping methods have been used for this purpose.  
15 The shaping techniques according to the prior art include sinking under its own  
weight, pressing, imprinting or vacuum drawing.

A substantial disadvantage of the method of sinking under its own weight  
is the limited degree of shaping that can be obtained. Only limited forms can be  
obtained, especially sharp edged shapes or narrow radii.

20 The main disadvantage of the pressing and imprinting methods is that a  
forming material or tool must come into contact with the surface of the glass or  
the glass-ceramic part so that there is an inherent quality loss at the surface.

The disadvantage of vacuum drawing is the necessity of positive contact with the edge region or rim of the glass or glass-ceramic part around the shaping region, so that no vacuum loss arises at the onset of the shaping process.

Usually the process is exclusively used for drawing softened glass and/or glass-ceramic masses into cavities of a mold that is planar at the edges.

5 A process and associated apparatus for making glass bodies for electronic tubes, especially display screen parts, are disclosed in DE 25 28 421 A1. In this process a substantially planar glass plate is received in a holding or clamping unit at its rim or edge region as a starting product (semi-finished product). It is

10 then heated over the softening point of the glass in a burner and then shaped by means of a suitably formed die or press member. The holding or clamping unit is generally formed so that overpressure or under pressure can be produced in the space under the glass plate, whereby the shaping process of the glass plate can also be influenced. In case of an under pressure an actual vacuum drawing

15 method is described.

These known methods however cannot be used for the partial shaping of flat glass and/or comparable glass-ceramic articles or parts.

## SUMMARY OF THE INVENTION

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It is an object of the present invention to provide a process and associated apparatus of the above-described kinds for partial shaping of a glass or glass ceramic article, so that concave contours of a complex nature can be provided in

a flat glass or glass ceramic article by bringing a shaping die or tool into contact with only one side of the flat glass or flat glass ceramic article.

This object and others, which will be made more apparent hereinafter, according to one aspect of the present invention, are attained by a process for  
5 partial shaping of a flat glass part or a glass ceramic part comprising the steps of:

a) placing a flat glass or glass ceramic article on a planar support with an entire facing surface of the flat glass or glass ceramic article resting fully on the planar support, the planar support having at least one through-going shaping opening in a shaping region;

10 b) producing a low pressure in a space below the planar support to hold the flat glass or glass ceramic article fixed on the planar support;

c) partially heating the flat glass or glass ceramic article in the vicinity of the shaping region on the planar support until at least a part of the flat glass or glass ceramic article softens;

15 d) providing at least one shaping die in the at least one through-going shaping opening in the planar support in an initial position below the flat glass or glass ceramic article on the planar support prior to the partial shaping, preferably with a gap between the at least one shaping die and a respective edge of the planar support at the at least one through-going opening to assist in fixing or  
20 holding the flat glass or glass ceramic article on the planar support by means of the low pressure;

e) raising the at least one shaping die provided in the at least one through-going shaping opening over a predetermined distance into the softened part of

the glass or glass ceramic article at the same time as the producing of the low pressure in the space below the planar support;

5       f) then cooling a partially shaped glass or glass ceramic product formed from the glass or glass ceramic article by the heating, the low pressure and the raising of the at least one shaping die;

g) withdrawing the at least one shaping die from a solidified portion of the partially shaped glass or glass ceramic product; and

h) removing the partially shaped glass or glass ceramic product from the support plate.

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The above object and others, which will be made more apparent hereinafter, according to another aspect of the present invention, are attained by an apparatus for partial shaping of flat glass or comparable glass ceramic parts comprising

15       a planar support plate for receiving and supporting a flat glass or glass ceramic article so that the flat glass or glass ceramic article rests with an entire surface thereof fully on the planar support plate, the planar support plate being arranged over a substantially airtight hollow compartment and having at least one through-going shaping opening to the substantially airtight hollow compartment;

20       a respective shaping die engaged in each of the at least one through-going shaping opening with a predetermined peripheral gap between each shaping die and the planar support plate, so that each shaping die is substantially flush with an upper surface of the planar support plate in an initial

position and is movable upward from that initial position to extend to a predetermined displaced position above the upper surface of the planar support plate;

vacuum-producing means for producing a low pressure in the airtight

5 compartment;

heating means for partially heating the glass or glass ceramic article in the vicinity of the at least one through-going shaping opening prior to performing the partial shaping; and

ejecting means for removing a finished glass or glass ceramic product

10 from the planar support plate after the partial shaping.

The features according to the invention not only facilitate the formation of concave contours or shapes in cavities by vacuum drawing or suction, but also at the same time permit the formation of raised or embossed regions with tight radii and complex contours while only contacting the shaping tool or die on a bottom

15 side of the article.

In a preferred embodiment of the process a rapid and effective heating of the glass or glass ceramic article takes place by means of IR radiation or gas burner.

An accurate shaping is possible in the process according to the invention  
20 when a partial heating to reach a glass or glass ceramic material viscosity below  $10^6$  dPa·s is performed.

In the case of glass ceramic articles in a preferred embodiment of the process the heating is performed during a time interval of less than 30 s, because of the great tendency of glass ceramic material to crystallize.

In preferred embodiments of the process for partial shaping the cooling of  
5 the partially shaped glass or glass ceramic product is assisted by blowing air or directing an air stream at the partially shaped glass or glass ceramic article so that the processing time is short.

To guarantee a reliable and safe removal of the partially shaped glass or glass ceramic product the glass or glass ceramic product is raised by means of  
10 lifting pins or members and/or by action of compressed air.

Various embodiments of the apparatus for partial shaping of the glass or glass ceramic article are possible.

In order to provide the highest possible service life the planar support plate and shaping die are made from heat-resistant metal or a ceramic material.

15 The operation of the shaping die is especially easy when a vertically movable base plate is arranged in the airtight hollow compartment so that it can travel vertically in the airtight hollow compartment. A ram is rigidly connected with the shaping die or dies, whose length determines the shaping height or depth in the softened glass or glass ceramic article. The ram is mounted on or attached to  
20 the base plate, so that the shaping die or dies move upward from an initial position into the softened glass or glass ceramic article when the base plate moves vertically upward.

In preferred embodiment of the apparatus according to the invention the support plate and/or the shaping die has additional passages or holes and/or is made from a porous material in order to provide the most secure support of the glass or glass ceramic article during shaping.

5 In various advantageous preferred embodiments of the apparatus lifting pins or members and/or means for supplying compressed air are provided in order to provide a safe and secure removal of the partially shaped glass or glass ceramic product from the apparatus.

## **10 BRIEF DESCRIPTION OF THE DRAWING**

The objects, features and advantages of the invention will now be illustrated in more detail with the aid of the following description of the preferred embodiment, with reference to the accompanying sole figure, which is a cross-sectional view through a preferred embodiment of the apparatus for partial shaping of a glass or glass ceramic article or part according to the invention.

## **DESCRIPTION OF THE PREFERRED EMBODIMENT**

20 The preferred embodiment of the apparatus for partial shaping of glass or  
glass ceramic parts shown in the figure includes a support plate 1, preferably  
made of a heat-resistant metal, e.g. 17 % chromium steel, or from ceramic  
material, e.g. from silicon dioxide. The support plate 1 is arranged over a

substantially airtight hollow compartment 2. However the support plate 1 is provided with a plurality of through-going holes or through-going shaping openings 3. Shaping dies 4 are arranged in the respective holes 3, which are made from the above-described material, and fit in the respective holes 3 with a 5 comparatively small gap G between them and the adjacent edge of the support plate 1. At the beginning of a shaping process the shaping dies 4 are in an initial position flush with an upper surface of the support plate 1. A planar glass sheet 5 to be partially shaped rests with its surface fully on the support plate 1.

During the shaping a vacuum or low pressure is produced in the nearly 10 airtight hollow compartment 2 under the support plate 1 by a pump or vacuum-producing device 10. The glass sheet 5 is thus drawn down onto the support plate 1 and held there.

The glass sheet 5 to be partially shaped, at least in the shaping region in the vicinity of the shaping dies, is heated by a heating means 9, until it softens, 15 i.e. until the viscosity of the glass is preferably below  $10^6$  dPa·s. The heating means 9 is preferably an IR radiator or a gas burner. In the case of a glass ceramic article this heating process should be performed very rapidly (< 30 sec) to about  $1000^\circ\text{C}$  because of the higher tendency of the glass ceramic material to crystallize. Thus high heating power (up to  $1 \text{ MW/m}^2$ ) is usually required in the 20 case of glass ceramic articles.

A base plate 6 is provided under the hollow compartment 2, on which a ram or rams 7 are arranged. The shaping die or dies 4 are firmly attached to the ram or respective rams 7. During the partial shaping the base plate 6 is raised far

enough so that the shaping die or dies 4 are lifted or raised by means of the ram or rams 7 over the desired predetermined shaping distance. Different embodiments can provide different shaping depths or heights in the glass or glass ceramic article with different base plates 6 having different rams of different lengths for several shaping dies 4.

The drawing force provided by the vacuum or low pressure in the hollow compartment 2 can act on the glass article 5 because of the gap G formed between the shaping die 4 and the support plate 1 at the respective through-going shaping openings 3 in the support plate 1. Additional holes provided in the 10 shaping dies 4 and/or the support plate 1 assist in permitting the suction to act on the glass sheet or article 5 to be partially shaped. Furthermore if the support plate 1 and/or the shaping dies 4 are made of porous material the suction can act even more easily on the glass article 5.

According to the particular side of the glass or glass ceramic article that 15 rests on the support plate 1 or is actually used, depressed regions or raised regions are formed in the facing side of the glass or glass ceramic article.

After subsequent solidification of the glass sheet or article because of cooling after turning the heating means off, the shaping die or dies 4 are withdrawn by lowering the base plate 6. Then the partially shaped glass product 20 is raised by means of lifting members 8 so that it can be removed from the apparatus. Alternatively or in addition, compressed air can be used to remove the shaped glass article.

The remaining parts of the apparatus that have not been described are conventional components of a unit for glass processing, for example the movable machine beds, the associated warming ovens, etc.

The disclosure in German Patent Application 101 10 357.3-45 of March 3, 5 2001 is incorporated here by reference. This German Patent Application describes the invention described hereinabove and claimed in the claims appended hereinbelow and provides the basis for a claim of priority for the instant invention under 35 U.S.C. 119.

While the invention has been illustrated and described as embodied in a 10 process for partial shaping of flat glass or glass-ceramic articles and apparatus for performing same, it is not intended to be limited to the details shown, since various modifications and changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the 15 present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed is new and is set forth in the following appended claims.